

## ORGANIZATION OF ENERGY EFFICIENT ECOLOGICAL SETTLEMENTS WITH PREFABRICATED MODULAR BUILDINGS FOR TEMPORARY AND LONG-TERM LIVES OF LIVING, IN CONNECTION WITH THE WAR IN UKRAINE

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**Abstract.** The cities of Ukraine are our pride! It was the envy of prominent Ukrainian cities that provoked the aggressor's attack on our native lands. It should be noted that most Russian cities, which are more remote, cannot be proud of their amenities: there is no sewerage or water supply, unpaved streets quickly turn into swamps of sticky dirt. On the 24<sup>th</sup> of February 2022, the war began, and Russian Federation attacked Ukraine on all sides of the common border, from Luhansk to Chernihiv. The enemy army fired artillery at Ukrainian border posts. Hometown Kharkiv is a city in the northeast, the first capital, the scientific center of Ukraine, subjected to massive bombing. Every day the occupiers purposefully destroy more and more civilian infrastructure, because of which the evacuation began. The news notes that in the first days of the war, every day about 30,000 people go from the Kharkiv railway station to safe places, to the west of the country and abroad. That is why the article considers the best ways to develop the territories of the western part of the country, through the organization of energy-efficient ecological settlements with prefabricated modular buildings for temporary and long-term residence of people who lost their homes because of the war. In the formation of energy-efficient ecological settlements, the main basic aspects are laid down, including: minimization of impacts on the existing natural environment, use of processes on the way to improving urban planning, implementation of rational spatial solutions, ensuring resilience of settlements to disasters and war, application renewable energy sources (use does not lead to additional heating of the atmosphere, so this energy is waste-free and does not pollute the atmosphere), ensuring efficient water supply and rational use, development of underground space and conservation of natural areas. innovative living space, with the necessary, comfortable conditions that will serve for the development of new territories and for the revival of destroyed territories because of the war.

**Key words:** war in Ukraine, energy efficient ecological settlements, compact housing, mountain territory, modular building.

**Introduction.** We are living in a period of instability: it seems that only yesterday we suffered from a terrible pandemic, climate change, accelerating the loss of biodiversity, and now from predatory fighting in our homeland.

Many people lost their homes and were forced to evacuate to western Ukraine and abroad. In order to provide housing for all those in need in the west of our country, architects, builders and urban planners have a number of tasks, including developing the necessary recommendations, economic, comfortable and project proposals for rapid implementation. Energy efficient ecological settlements are exactly the option of economical and comfortable living environment that should be developed. Designing energy-efficient ecological settlements is a new field of knowledge that is currently being developed. The concept of sustainable energy-efficient ecological settlement should play a growing role in the future development of territories in all regions of our country, in the future and around the world. In this article we will try to find the best ways to develop the territories of the western part of the country, through the organization of energy-efficient ecological settlements with prefabricated modular buildings for temporary and long-term residence, which have less impact on the environment. Some aspects are important in this regard: economic feasibility, short-term construction, reduction of energy consumption and reduction of waste and

further management.

The concept of energy-efficient ecological settlements has an undeniable impact and serves as an alternative sustainable model of residential areas. As a relatively small experimental example, these urban planning entities could explore and apply new solutions, the need for which is evident in the global care for migrants.

**Analysis of recent research and publications.** Analysis of recent research and publications. David Adams is a planner and geographer, researching the reconstruction and experience of the urban environment. His research interests include urban theory, spatial and architectural planning. He pays special attention to the formation of urban and suburban areas, as well as reconstruction after the Second World War in Britain, including the restoration of infrastructure. Peter Larkham has a variety of research interests, covering various aspects of spatial planning. He has long been interested in ecology, environmental protection, and focuses on redevelopment and reconstruction of British cities after World War II. That is why David Adams and Peter Larkham wrote the book "Everyday Experience of Reconstruction and Regeneration. From Vision to Reality in Birmingham and Coventry", which highlighted the process of design and reconstruction, reconstruction of new models of cities after World War II [1].

Prefabricated housing was popular during World War II due to the need for mass deployment of troops. The United States used the huts as military buildings. Prefabricated buildings were built after the war as a means of providing fast and cheap quality living environment to replace destroyed housing. The spread of prefabricated housing throughout the country was a consequence of the Bert Committee and the Housing Act (Temporary Housing) of 1944 [2].

Many Eastern European countries suffered physical damage during World War II, and their economies were in very poor shape. There was a need to rebuild cities that were badly damaged by the war. For example, Warsaw was virtually razed to the ground during the planned destruction by German troops (1944), and the center of Dresden was destroyed by Allied bombing (1945), Stalingrad was largely destroyed, and only a small number of buildings survived. Back then, prefabricated buildings served as an inexpensive and quick way to recover from massive housing shortages due to war destruction, large-scale urbanization, and rural exodus [3].

For rapid construction of the western part of Ukraine, the paper proposes to consider in detail the following types of housing on the example of prefabricated structures. Lisby Taylor, who studies modern methods of designing prefabricated buildings, identified the following categories of design solutions [4, 5]:

1. Modular design: manufacture of three-dimensional units in controlled factory conditions before transportation to the site.
2. Panel construction: flat panels are manufactured at the factory and assembled on site to create a three-dimensional structure.
3. Hybrid design: combines panel and modular designs.
4. Manufactured structures (assemblies and components) off-site – the manufacture of individual components or components, such as roof cassettes, prefabricated reinforced concrete foundations, except for window, door sets, roof trusses.

**Purpose and objectives.** The aim of the study is to identify the best ways to develop the western part of the country, through the organization of energy-efficient ecological settlements with prefabricated modular buildings for temporary and long-term residence.

Based on the goal, it is necessary to solve the following tasks:

1. Investigate the main ways of developing the western part of Ukraine.
2. To reveal the main aspects of the organization of energy efficient ecological settlements in mountainous areas.
3. Consider ways to place prefabricated modular buildings in mountainous areas for temporary and long-term residence.

**Research results.** Energy-efficient ecological settlements could be of strategic importance for the restoration of mountainous western regions of Ukraine. Mountainous areas are a natural, historical, cultural and economic heritage, based on appropriate management to promote the sustainable

development of these areas and the planet. The mountains are home to one-fifth of the world's population and are a source of fresh water for half of all people. Sustainable mountain development [6] means the wise use of mountain ecosystems for the present generation, preserving them for future generations.

The mountains were recognized as vulnerable ecosystems of global importance at the 1992 United Nations Conference on Environment and Development in Rio. The importance of the mountains was confirmed at the UN Rio + 20 conference in 2012. The protection of mountain regions is also enshrined in the 2030 Agenda for Sustainable Development [7].

Mountain ecosystems are extremely diverse. They are also very sensitive to climate change, natural disasters, industrial exploitation, migration (especially mountain-plain migration) and mass tourism. These phenomena often threaten entire mountain regions, endangering the lives of many people. Alpine populations, which are directly dependent on local water, soil, flora and fauna, suffer the most. But people at lower altitudes also benefit from healthy ecosystems in the mountains: for example, water supply, as about half of the world's population depends on the water resources of mountainous regions [8].

When designing energy-efficient ecological settlements in mountainous areas, the main, basic aspects are laid down, including: minimization of impacts on the existing natural environment, use of processes to improve urban planning, implementation of rational urban planning solutions, use of renewable energy sources., so this energy is waste-free and does not pollute the atmosphere). Energy resources, depending on energy sources, can be classified as renewable (solar energy, photosynthesis, hydropower, wave energy, wind, geothermal, evaporation and precipitation, thermal energy, use of temperature difference between atmosphere, land and sea, bioenergy) and other gas, oil, coal, peat, shale, nuclear fuel, light chemical elements – hydrogen, helium, lithium) [9]. Today, the main sources of energy are: coal, oil, natural gas, nuclear fuel, but the reserves of these resources are limited. In addition, the use of non-renewable energy sources leads to additional heating of the atmosphere. Recently, scientists are looking for the best way to use energy resources that will not harm the environment. That is why modern urban planning activities are aimed at preserving the natural environment of mountainous areas, in other words, the ecological approach is the basis of all urban development processes.

The use of mountainous areas, including areas that cannot be used for agricultural land, recreational areas, reserves, forestry, or other areas that require small slopes, are suitable for the organization of energy-efficient ecological settlements. Among the advantages, these areas can serve as an impetus for original architectural and structural solutions, such as incorporating buildings into the terrain of the existing area, increase the resistance of buildings to external influences (seismic, landslides, etc.). Depending on the engineering and geological characteristics of the soils of the projected area, as well as the slope of the territory, you can build different types of buildings: ordinary - for a flat surface, terraced of different types, on pillar supports and attached to steep slopes with tight anchors. Terraced buildings made of monolithic reinforced concrete should be built on sites with steep slopes, the soils of which can be varied [10, 11].

Prefabricated houses are built off-site in advance, usually in standard sections that can be easily transported and assembled on site. Some current prefabricated house designs include architectural details inspired by postmodernism or futuristic architecture. Because these houses are built in parts, this makes it easy to connect additional rooms or even solar panels to the roof. Prefabricated houses can be customized according to specific terrain and climatic conditions.

Prefabricated buildings are buildings that are constructed of components (such as panels), modules (modular buildings) or transport sections (industrial buildings). Despite the similarities, the methods, and designs of these three types are very different. There are two-storey and individual houses, which differ significantly in design. In the United States, mobile and prefabricated houses are built in accordance with HUD building codes [12], and modular houses are built in accordance with the IRC (International Housing Code) [13].

First, when designing prefabricated modular buildings in mountainous areas, attention should be focused on natural resources such as topography, engineering and geological conditions, soils,

vegetation, groundwater and surface water, climate, wind, insolation, temperature, etc. Modern architects are experimenting with prefabricated buildings in factories to develop the best option for mass construction in mountainous areas. Architectural solutions are devoid of reference decor and instead focus on clear lines and open floor plans. An example of a building and a method of placing a prefabricated modular building in mountainous areas for temporary and long-term residence is shown in Figure 1. The characteristics of these components affect urban processes, creating conditions for placing in such areas different activities that determine construction conditions and affect the planning structure resettlement. The main aspect of placing prefabricated modular buildings in energy-efficient ecological settlements is the level of insolation - the amount of solar radiation per square meter of surface, as it affects the ability of the settlement to be autonomous by placing solar photovoltaic panels on the roof at the right angle [10].

The climate and geographical location of mountain areas should be conducive to favorable conditions for the optimal absorption of solar energy and the construction of energy-efficient ecological settlements and the use of solar panels. Therefore, direct solar heating is the simplest way of non-traditional heating [11]. The sun's rays, entering the house through the glazing, heat the room, while the glass surface must be oriented to the south. The heat accumulator is the floor and interior walls made of material with high heat capacity. To protect the building from overheating in the summer, it is necessary to provide sun protection devices, such as awnings, visors, greenery, or adjustable structures. Insulating windows or special films should be provided to protect against heat loss at night.

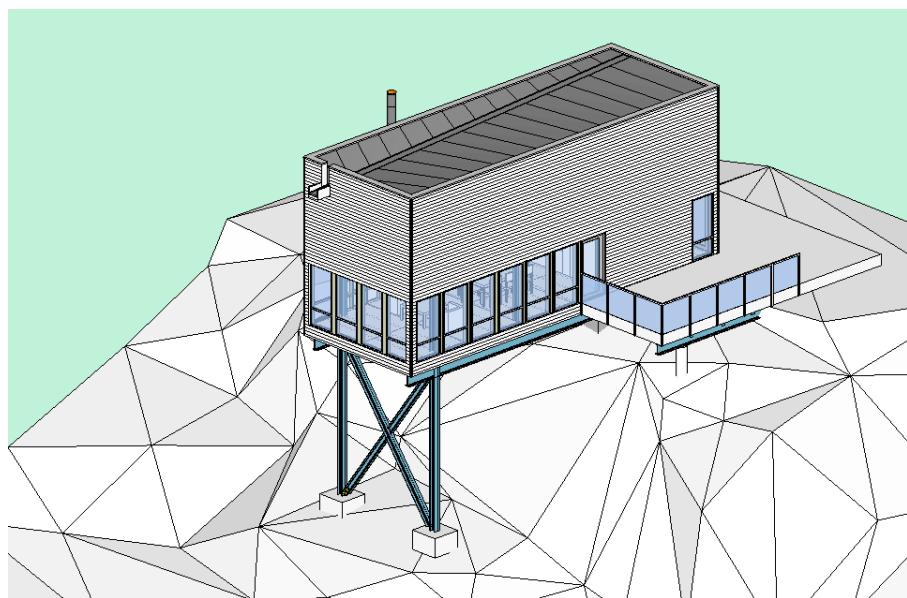


Fig. 1. Prefabricated modular building on steep terrain

Energy efficiency of prefabricated modular buildings is periodically implemented in many countries around the world, which consume much less than the total primary energy. The construction of prefabricated modular buildings is gaining popularity due to rapid construction, architectural solutions, reliability and use of "green" materials, safe work of workers, and limiting the impact on the environment compared to conventional construction. From the point of view of building physics, three-dimensional systems of prefabricated structures, thanks to the prefabricated method minimize thermal bridges [14, 15].

The interior of the prefabricated modular building (Fig. 2) has all the necessary conditions for a comfortable life, both for short and long life. The prefabricated modular building is aimed at the average family – it has an entrance hall, two bedrooms (parents and children), a bathroom, a separate toilet, a living room, and an equipped kitchen.

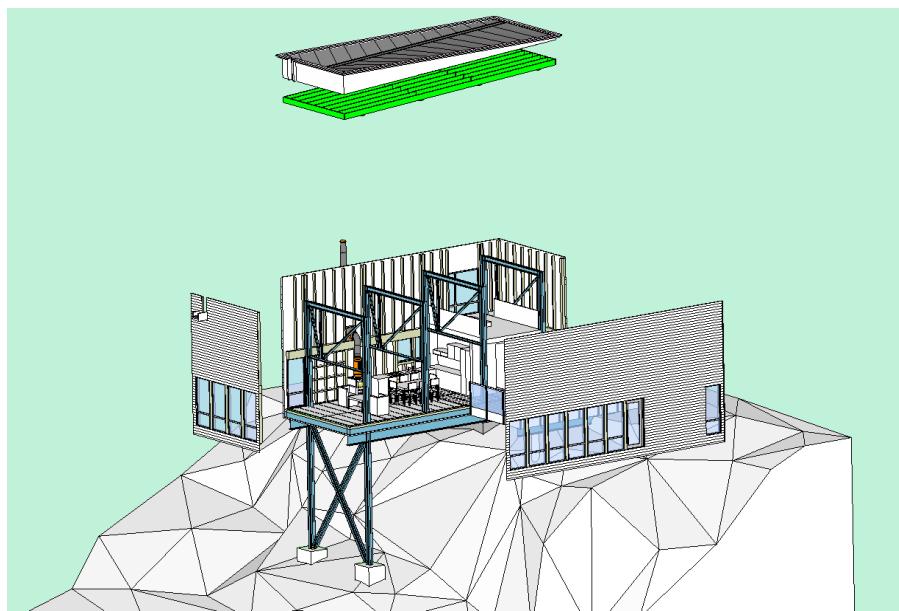


Fig. 2. Interior decoration of the prefabricated modular building

**Conclusions.** It should be noted that the scientific activity of our city continues, we believe in victory, and are infinitely grateful to our heroes – the Armed Forces of Ukraine!!! This is the most difficult period of today, will forever leave a mark on the body of the country. Incredibly dangerous, controversial times will be remembered not only by fires, lost buildings, and property, but also by the long, painstaking work of urban planners, architects, builders, and gardeners who will recreate the grandeur of stone – in short, everything we see today.

To begin the revival, as noted by most residents from the east evacuated to western Ukraine, people need to be provided with comfortable living conditions. Innovative urban planning formations – energy efficient ecological settlements in the mountainous areas of the western part of Ukraine are the best option for both short-term and long-term living. And prefabricated modular buildings are an appropriate type of housing for people who lost their homes because of the enemy war, as this type of building is quite popular in Europe, Canada, and the United States, due to the rapid implementation and return on investment.

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**ОРГАНІЗАЦІЯ ЕНЕРГОЕФЕКТИВНИХ ЕКОЛОГІЧНИХ ПОСЕЛЕНЬ  
ЗІ ЗБІРНИМИ МОДУЛЬНИМИ БУДІВЛЯМИ  
ДЛЯ ТИМЧАСОВОГО ТА ДОВГОСТРОКОВОГО ПРОЖИВАННЯ  
В ЗАХІДНІЙ ЧАСТИНІ КРАЇНИ, У ЗВ'ЯЗКУ З ВІЙНОЮ В УКРАЇНІ**

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**Анотація.** Міста України – це наша гордість! Саме заздрість до визначних українських міст спровокувала напад країни агресора на наші рідні землі. Слід зазначити, що абсолютна більшість російських міст, які є більш віддаленими, не можуть пишатися своїм благоустроєм: там не має ні каналізації, ні водопроводу, немощені вулиці швидко перетворюються на болота липкого бруду. 24 лютого 2022 року, розпочалася війна, Російська Федерація напала на Україну по всі боки спільногого кордону, від Луганська до Чернігова. Ворожа армія обстріляла із артилерії українські прикордонні застави. Рідне місто Харків – це місто на північному сході, перша столиця, науковий центр України, зазнало масових бомбардувань. З кожним днем окупанти цілеспрямовано все більше знищують цивільну інфраструктуру, внаслідок чого, почалася евакуація. В новинах зазначають, що в перші дні війни, кожного дня близько 30 тисяч людей відправляються із вокзалу Харкова до безпечних місць, на захід країни та закордон. Саме тому, в статті розглянуто оптимальні способи освоєння територій західної частини країни, завдяки організації енергоефективних екологічних поселень зі збірними модульними будівлями для тимчасового та довгострокового проживання людей, які внаслідок війни позбулися свого житла. При формуванні енергоефективних екологічних поселень закладені основні, базові аспекти, серед яких: мінімізація впливів на існуюче природне середовище, використання процесів, на шляху щодо вдосконалення містобудівної діяльності, впровадження раціональних об'ємно-просторових рішень, забезпечення стійкості поселення, до катастроф та війни, застосування відновлюваних джерел енергії (використання практично не призводить до додаткового нагрівання атмосфери, тому ця енергія є безвідходною, та не забруднюючою атмосферу), забезпечення ефективного водопостачання та раціонального користування, освоєння підземного простору та збереження природних ділянок. Тому, дане містобудівне утворення доцільно розглянути, як комфортний інноваційний житловий простір, з необхідними, комфортними умовами, який слугуватиме, для освоєння нових територій, так і для відродження зруйнованих територій внаслідок війни.

**Ключові слова:** війна в Україні, енергоефективні екологічні поселення, компактна житлова забудова, гірська територія, збірна модульна будівля.

**ОРГАНИЗАЦІЯ ЕНЕРГОЕФЕКТИВНИХ ЕКОЛОГІЧЕСКИХ ПОСЕЛЕНИЙ  
С СБОРНЫМИ МОДУЛЬНЫМИ ЗДАНИЯМИ  
ДЛЯ ВРЕМЕННОГО И ДОЛГОСРОЧНОГО ПРОЖИВАНИЯ  
В ЗАПАДНОЙ ЧАСТИ СТРАНЫ, В СВЯЗИ С ВОЙНОЙ В УКРАИНЕ**

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**Аннотация.** Города Украины – это наша гордость! Именно зависть к выдающимся украинским городам спровоцировала нападение страны агрессора на наши родные земли. Следует отметить, что абсолютное большинство российских городов, которые являются более отдаленными, не могут гордиться своим благоустройством: там нет ни канализации, ни водопровода, немощёные улицы быстро превращаются в болота липкой грязи. 24 февраля 2022 года, началась война, Российская Федерация напала на Украину со всех сторон общих границ, от Луганска до Чернигова. Вражеская армия обстреляла из артиллерии украинские пограничные заставы. Родной город Харьков – это город на северо-востоке, первая столица, научный центр Украины, подвергся массовым бомбардировкам. С каждым днем оккупанты целенаправленно все больше уничтожают гражданскую инфраструктуру, в результате чего началась эвакуация. В новостях отмечают, что в первые дни войны каждый день около 30 тысяч человек отправляются с вокзала Харькова в безопасные места, на запад страны и заграницу. Поэтому, в статье рассмотрены оптимальные способы освоения территорий западной части страны, благодаря организации энергоэффективных экологических поселений со сборными модульными зданиями для временного и долгосрочного проживания людей, которые в результате войны лишились своего жилья. При формировании энергоэффективных экологических поселений заложены основные, базовые аспекты, среди которых: минимизация влияний на окружающую природную среду, использование процессов, на пути совершенствования градостроительной деятельности, внедрение рациональных объемно-пространственных решений, обеспечение устойчивости поселения, к катастрофам и войне, применение возобновляемых источников энергии (использование практически не приводит к дополнительному нагреву атмосферы, поэтому эта энергия является безотходной, и не загрязняющей атмосферу), обеспечение эффективного водоснабжения и рационального пользования, освоение подземного пространства и сохранение природных участков. Поэтому, данное градостроительное образование является инновационным жилым пространством, с необходимыми, комфортными условиями, которое будет служить для освоения новых территорий, так и для возрождения разрушенных территорий в результате войны.

**Ключевые слова:** война в Украине, энергоэффективные экологические поселения, компактная жилая застройка, горная территория, сборное модульное здание.

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